FAST QUASI-AUTOMATIC 3D RECONSTRUCTION OF BODY SHAPE FROM BIPLANAR X-RAYS

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Introduction

Personalized 3D reconstruction of human body (see Fig. 1) is of major interest for biomechanical engineering. For example, it enables to assess the gravity line and body segments parameters without any additional device. Such a 3D model can be obtained using a body scanner. However, this modality does not permit to assess the internal geometry of the subject.

Low-dose biplanar X-rays is an efficient alternative since it enables to reconstruct bony structures in 3D and recently, Nérot et al. [1] proposed a reliable method for human body shape. However, since it requires many manual adjustments, it remains time consuming (20min). The aim of this study is then to introduce a faster and quasi-automatic method.

Figure 1: 3D reconstruction of human body shape from biplanar X-rays.

Materials and methods

We have collected pairs of biplanar X-rays (EOS system) of 73 women and 50 men of various ages and morphologies in a standard position. For validation purpose only, 172 radio-opaque markers were uniformly placed on 12 volunteers' skin. A Wii balance board was also placed in the EOS system for these subjects to assess the centers of pressure.

We have reconstructed the 3D body shape of each subject using the method presented in [1]. Additional descriptors are computed. A set of anatomical landmarks on the spine and at the main joints are represented by 3D points in the model. Moreover, some contours points on both radiographs at different levels of the human body are descripted by rays (origin of the X-ray source and a director vector). We have followed the recommendation of [2] to build two distinct statistical shape models (SSM) – male and female - from this data set.

In the reconstruction process, an operator first identifies the subject's sex and few anatomical landmarks of the radiographs. Manual annotations and automatic segmentation enable to estimate the descriptors of the model presented above. Second, we fit our SSM to the descriptors using [2] to obtain a first estimate of the subject's body shape. Third, the obtained solution is refined by automatic matching between the retro-projected contours of the model and the apparent contours on the radiographs. Finally, the operator can refine the solution if necessary by adjusting manually control points of the model.

Evaluation and Results

For the 12 volunteers, we evaluate this process by computing average and standard deviations for signed distance between the radio-opaque markers and the generated 3D surfaces at different regions (see table 1). Since they are part of the training step of the algorithm, we apply a leave-one-out process. Additionally, we compute centers of pressure of this avatar and compare them to the values given by the Wii board.

	Thorax	**Abdomen**	**Thighs**	**Calves**
Women	0±6.8	1.3±6.8	0.5±5.5	0.2±2.9
Men	0.6±6.9	1.1±6.5	1±6.3	1±3.7

Table 1 Average signed distance (in mm) by region between the radio-opaque markers and the 3D body shape ± 1sd.

The average distance between these centers of pressures for the 12 subjects is 5.2mm and the standard deviation is 2.7mm.

Discussion

The presented method offers similar accuracy than the method presented in [1] but it requires around five times less operator time. This methodology is easily extendable to the case of 3D reconstruction of human body shape from a couple of optical images.

References

1. A. Nérot *et al.*, J. of Biomech, 48;4322-4326, 2015.
2. T. Albrecht *et al*, Med. Im. Anal.,17(8) ;959-973, 2013.

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